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In re Patent Application of	)	
Håkan ERICKSSON et al.	)	Group Art Unit: 3722
Application No.: 09/838,305	)	Examiner: Unassigned
Filed: April 20, 2001	)	
For: CUTTING, TOOL SYSTEM AND MECHANISM FOR ACCURATELY POSITIONING A CUTTING EDGE	)	

OIPE JC68 JUN 2 9 2001 PATENT & TRADEMARK OFFICE

CLAIM FOR CONVENTION PRIORITY

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

The benefit of the filing date of the following prior foreign application in the following foreign country is hereby requested, and the right of priority provided in 35 U.S.C. § 119 is hereby claimed:

Swedish Patent Application No. 0001473-8

Filed: April 20, 2000

In support of this claim, enclosed is a certified copy of said prior foreign application. Said prior foreign application was referred to in the oath or declaration. Acknowledgment of receipt of the certified copy is requested.

Respectfully submitted,

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Härmed intygas att bifogade kopior överensstämmer med de handlingar som ursprungligen ingivits till Patent- och registreringsverket i nedannämnda ansökan.

This is to certify that the annexed is a true copy of the documents as originally filed with the Patent- and Registration Office in connection with the following patent application.

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För Patent- och registreringsverket
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CUTTING TOOL SYSTEM AND MEANS OF ACCURATELY POSITIONING THE SAME

TECHNICAL FIELD OF THE INVENTION

This invention relates to a system for rapidly and accurately establishing the correct position of the operative cutting edge on tools for chip forming metal machining and in particular those used for internal turning such as boring bars which are clamped in tool clamping devices. Said cutting tools comprising a shaft and at least one cutting edge at least at one end of the shaft. The said, at least one cutting edge, being either on a cutting insert which can be attached to the cutting tool mechanically, for example by use of a screw or metallurgically, for example by use of welding or the cutting edge can be an integral part of a solid, one piece tool. The first embodiment of the invention involves a cutting tool having an operative cutting edge that is positioned offset from the longitudinal axis of the cutting tool and at a greater distance from said axis than any other part of the tool. The cutting tool is held in place in the machine tool by a tool-clamping device in which it can be rotated around its longitudinal axis prior to being clamped in position. A relatively minor angular adjustment of the cutting tool has a significant effect on the position of the operative cutting edge of the insert in relation to a horizontal plane running through the longitudinal axis of the cutting tool. The present invention ensures the exact and rapid positioning of the edge. Other embodiments of the same invention ensure the exact distance of the cutting edge from the tool-clamping device that is to say the overhang or combinations of the angular adjustment and the overhang.

BACKGROUND TO THE INVENTION AND PRIOR ART

Internal turning operations differ significantly from external turning operations in several features and these must be taken into consideration if internal turning operations are to be optimized. Firstly there is a limited space inside the workpiece. This influences the design of the cutting tool; it is essential that the optimum compromise between maximum strength/rigidity and minimum volume be found. In practice the solution is a bar, which is cylindrical in cross section, and in practice most bars are substantially cylindrical although one or more longitudinal planar surfaces which are parallel to the longitudinal axis of the bar may be incorporated. Said surfaces to be used to fix the rotational position of the bar in the tool-clamping device. Thus the need to be able to fix exactly the rotational position of the bar and hence the height of the operative cutting edge in such cases is achieved at the expense of a somewhat weaker design of the bar.

The limited space inside the workpiece within which the tool must operate also makes chip forming, chip flow and chip breaking far more critical than in external turning operations since failure of any of these can lead to chip jamming, damaged tools, poor finish on the machined surfaces and tool vibration. Tool manufacturers put considerable effort into designing cutting inserts and tool holders for internal turning operations which minimize these problems but to be successful it is essential that the position of the cutting edge relative to the workpiece be exactly as the manufacturer intended.

Secondly internal turning operations differ from external ones in that vibration of the tool is always present and it has a major influence on tool life, surface finish and productivity. Incorrect positioning of the cutting edge may lead directly to cutting forces which differ from those for

which the tool was designed and the negative effects on chip forming listed above will also often lead to vibration.

SE 500 836 teaches the use of a spirit level in contact with a flat planar upper surface of a boring bar which is used to ensure that the operative cutting edge of the insert mounted on the cutting tool is clamped in a pre-determined position. This solution has the disadvantage (already mentioned) that the planar surface decreases the material in the bar and hence its strength. Furthermore the use of a spirit level is not desirable in the limited space and poor accessibility in a modern machine tool plus the difficulties of reading a spirit level because of the cooling fluid and chips.

WO 95/35179 teaches the use of a partially cylindrical boring bar with two planar longitudinal surfaces running parallel to the longitudinal axis of the bar. Said surfaces abutting against matching surfaces in a "V" shaped groove in the tool block. This solution also involves a weakening of the bar as described in the previous example.

SE 509 421 also teaches the use of a setting device to determine the angular position of a cutting tool and cutting edge. The cutting tool is locked in position in the device using a fixing element, which interacts with a cylindrical aperture in the envelope surface of the cutting tool. A rotatable disc with angular markings is then used together with a spirit level to determine the angular position of the cutting edge. This solution is time consuming to use and is not suitable for the limited space and poor accessibility in a machine tool.

THE AIMS AND FEATURES OF THE PRESENT INVENTION

The aims of the present invention are to eliminate the disadvantages of previously known methods for determining the exact position of the operative cutting edge.

The first objective is to create a system which can be used on a bar which is substantially cylindrical in other words the requirement of one or several planar reference surfaces or a deep "V" groove which weakens the bar is avoided. Secondly to have a system which is simple and lends itself to easy use in the confined space, poor lighting and dirty environment to be found in a machine tool. It can also be a useful aid for machine operators who are blind or have poor sight.

Thirdly to create a system that can be reasonably priced when supplied on new tools or as conversion kits for older installations.

These and other aims are achieved by a system of a cutting tool and a clamping device as defined in the characterizing part of claim 1.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIGURE 1 is a perspective view of prior art combination of cutting tool and tool clamping device.

FIGURE 2 is a perspective view of prior art showing another combination of cutting tool and tool clamping device.

FIGURE 3 is a perspective view of prior art showing another combination of cutting tool and tool clamping device.

FIGURE 4 is a perspective view of a cutting tool and tool clamping device according to the invention.

FIGURE 4a is a perspective view of an alternative application of the invention.

FIGURE 4b is a perspective view of an alternative application of the invention.

FIGURE 4c is a perspective view of an alternative application of the invention.

FIGURE 5 is a perspective view of an alternative application of the invention.

FIGURE 5a is a perspective view of an alternative application of the invention.

FIGURE 5b is a perspective view of an alternative application of the invention.

FIGURE 6 is a cross-sectional view of the cutting tool, tool-clamping device and spring loaded device.

FIGURE 7 is a detailed cross-sectional view of the first embodiment of the spring-loaded device

FIGURE 8 is a detailed cross-sectional view of a second embodiment of the spring-loaded device.

FIGURE 9 is a cross-sectional view of the locating device.

FIGURE 10 is a detailed cross-sectional view of the cutting tool in the tool-clamping device showing the means of measuring the cutting edge height.

Fig. 1 illustrates a typical prior art combination consisting of a cutting tool 1 for example a boring bar and a tool-clamping device 15. The cutting tool consists of a substantially cylindrical shaft portion 3 with front 9 and rear ends 11. The front end accommodates at least one cutting insert 5. The cutting tool 1 is located and secured in the tool clamping device 15 by means of at least one clamping screw 17 acting on a planar surface 13 on the upper side of the bar. The lower part of an aperture 23 in the tool block being V-shaped 21. This solution is commonly used but is not to be recommended since it gives a limited clamping force because of the restricted contact surface of the tips of the screws on the surface and poor location of the bar and hence poor repeatable accuracy of the height of the cutting edge.

Fig. 2 illustrates another prior art clamping method in which a substantially cylindrical cutting tool 1 is accommodated in a correspondingly substantially cylindrical

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aperture 23 in a tool block 15. Said block featuring a longitudinal split 19 along the entire length of one side. One or more screws 65 are arranged perpendicular to the split and pass from the upper surface of the block though non-threaded apertures and through the split and into threaded apertures on the block below the split. When the screws are tightened the split is caused to narrow and as a consequence the effective diameter of the aperture 23 is reduced. In this manner a clamping force is exerted by the inner surface of the aperture 23 onto a large contact surface of the substantially cylindrical shaft 3. This solution provides an excellent clamping force but no means of obtaining positional accuracy. To be able to accurately locate the height of the cutting edge 7 on the cutting insert 5 a reference surface and dial gauge are required.

In Fig 3 a prior art solution is shown which is similar to that in Fig.2 in that a cylindrical cutting tool 1 is located in the tool block but here a scribe line 25 has been provided the upper side of the bar running longitudinally and parallel to the axis of the boring shaft 3. A scribe line 27 is also provided on the front face of the tool block. When installing the cutting tool in the tool block the operator can visually align the scribe line on the cutting tool with that on the front face of the block and hence ensure that the height of the cutting edge 7 established with a certain degree of accuracy. The bar is then secured in the aperture in the tool block as described under Fig.2. In practical tests, as described below, it has been established that this method does not ensure acceptable repeatable accuracy of the height of the cutting edge.

Fig.4 illustrates a cutting tool and tool block according to the invention. The cutting tool 1 comprises a substantially cylindrical shaft portion 3 and a front portion 9. Said front portion comprises at least one cutting edge 7. The upper

envelope surface of the shaft is equipped with a recess 21 in the form of a "U" shaped groove, which runs parallel with the longitudinal centre axis of the bar. The groove has a symmetrical cross sectional form and the two side surfaces of the groove, as seen in cross section, are of equal length. The outer diameter of the cylindrical part of the cutting tool is denoted "d". The tool block 15 features an aperture 23, which runs the entire length of the block with openings both at the front 53, and rear 55 surfaces. The inner diameter of the bore "D" is somewhat larger than the outer diameter "d" of the cutting tool. A longitudinal split 19 links the bore to one of the side surfaces 57 of the tool block along the entire length of the tool block. One or more apertures are provided from the upper surface of the tool block running vertically downwards through the split 19 and into the lower part of the block. The lower part of said aperture being threaded to enable a screw 65 to be passed through the aperture in the upper part of the block 59 and be screwed into the lower part 61. The action of this or these screws being to force the parts of the block immediately above and below the groove together thus reducing the effective diameter "D" and clamping the cutting tool accommodated in said bore. Furthermore the tool-clamping device 15 features a bore 45 running vertically downwards from the upper surface of the block and opening up in the centre aperture which accommodates the bar. Said bore is located close to the front edge of the block where the upper surface 63 meets the front face 53 and its centre line cuts the centre line CL 2 of the aperture in the tool block. This bore accommodates a spring-loaded device 30, which is illustrated in more detail in Fig.6. The recess, in this case a groove interacts with the spring loaded device to give a slight but significant increase of the force required to rotate the cutting tool around its centre longitudinal axis as it passes the point of interaction. Once the correct location has been

thus established the cutting tool is clamped in the clamping device.

Fig. 4a illustrates a second embodiment of the invention in which the recess or recesses 21 are in the form of symmetrical, inverted, conical dimples in the envelope surface of the tool carrier with a basically "U " shaped cross section irrespective of whether the cross section of the cutting tool is taken along the length of the cutting tool or at 90 degrees to it. If a plurality of such dimples is used they are to be arranged in a line parallel to the centre line of the cutting tool and to be spaced at regular intervals for example 10 mm from each other. The positioning of the spring-loaded device is the same as in the embodiment described in Fig.4. and the interplay between the spring-loaded device and dimple is similar. Thus the device provides an indication in this case of both the rotational position of the cutting tool and the longitudinal position.

Fig. 4b illustrates a further embodiment of the cutting tool where, in this case, recesses in the form of "U" shaped grooves 21 positioned in the envelope surface of the shaft portion 3 and run all the way or part of the way round the shaft in a plane which is at right angles to the longitudinal centre axis of the cutting tool. The grooves to be spaced at regular intervals from each other, for example at 10 mm spacing. The interaction with the spring loaded device 30 is similar in this case to those described earlier with the exception that the solution described here can only be used for the longitudinal location of the cutting tool in the clamping device.

Fig. 4c illustrates a further embodiment of the invention that is very similar in design and function to that shown and described with Fig. 4b. The difference in this case being that the shaft portion of the cutting tool and the matching

aperture in the clamping device are prismatic rather than cylindrical. Recesses in the form of grooves 21 are provided on one or more of the planar faces of the cutting tool in a plane at right angles to the longitudinal centre line of the cutting tool. The interaction with the spring-loaded device can only be used for the longitudinal location of the cutting tool in the clamping device.

Figs. 5, 5a and 5b illustrate the invention as used in an arrangement that is especially suited for modern machine tools. In this case a sleeve 47 has been introduced between the bar and the tool block or tool adaptor 49. The sleeve is designed to accommodate a spring-loaded device 30, as also is the adaptor in exactly the same manner as described above for figure 4. As described previously the spring-loaded device is used only to give an indication of a required position prior to clamping the cutting tool. In this solution clamping is carried out with the help of the screws 65, which lock the sleeve in position through interaction with the planar surface of a whistle notch and at the same time exert a pressure on the sleeve causing the slit 19 to narrow hence clamping the cutting tool in the sleeve.

Fig. 6 and 7 illustrate a cross section through the cutting tool 1, clamping device 15 and the spring loaded device 30. The spring-loaded device is installed in bore 45 close to the upper front edge of the tool-clamping device. The position of the device in the bore is carefully adjusted to ensure the correct interplay between the spring-loaded device 45 and the dimple or groove 21 in the tool holder. The spring loaded device 30 consists of a housing 25 with an external thread and a groove 43 in the one end surface 37 said groove being designed to accommodate the tip of a screw driver which is to be used when screwing the spring loaded device into place in the tool block. The cylindrical housing has an aperture at its lower end into which a coil spring 31 and

sphere or cylinder 33 are mounted. When the aperture in the housing and the "U" groove or dimple 21 in the outer envelope of the cutting tool are inline the sphere will be pushed by the force of the spring partially into said groove. The size of the sphere and the depth and angle of the sidewalls of the groove are carefully chosen to ensure that the sphere does not become fixed in the groove. The combination is designed simply to give a mechanical and on occasions also a slight audible indication that the spring loaded device and groove are in line and hence the height and/or the longitudinal position of the operative cutting edge is correct. The mechanical indication is in the form of a slight but distinct increase in the manual force required to rotate the bar slightly round or parallel to the longitudinal axis when departing from the position where groove/dimple and spring loaded device are in line. The audible spring loaded device is a "click" sound heard when the sphere locates in the groove. Naturally it may not always be possible to hear the audible signal because of the high noise level in the machine tool.

Although contact between the spring loaded device and the groove 21 has been referred here to being via a sphere 33 it is possible to replace the sphere by a cylinder. Said cylinder would have to be mounted so that its centre axis was parallel with the centre axis of the boring bar. The supporting arrangement for this cylinder would be somewhat different from that for the sphere or cylinder of the main embodiment but its function would be the same.

Fig.8 is a detailed cross-sectional view of a second embodiment of the spring loaded device in interaction with the "U" groove on the circumference of the cutting tool in this particular case the construction of the spring loaded device has been simplified so that it consists of just a sphere or cylinder 33 and an elastic, for example rubber, cylindrical cap 51 which serves both to retain the sphere or cylinder in

place and allow the sphere or cylinder to move slightly upwards when a pressure is applied from below. The diameter of the aperture is reduced at the open end to ensure that the sphere 33 is retained in the aperture whilst still allowing the sphere to protrude sufficiently so that it can interact with the "U" -groove or dimple on the envelope surface of the cutting tool.

Fig. 9 is a cross section of the sphere or cylinder 33 of the spring loaded device and the cutting tool 1 showing the interplay between the sphere and the recess 21 substantially to scale. The diameter of the sphere or cylinder is typically in the range 2-5 mm and the recommended value 2,5 mm. The depth of the "U" shaped recess is typically in the range 0,01-0,2 mm and the recommended value is 0,04-0,06 mm. The point angle of the "U" shaped recess lies between 35-85°, preferably 55-65° and recommendably about 60°.

Fig. 10 illustrates how practical tests were carried out to assess the repeatable positional accuracy obtained using the spring loaded device according to the invention and the scribe line method. This figure shows the method as used with the system according to the invention. The cutting tool 1 is mounted in the tool clamping device 15 and the cutting tool position is brought into the desired position by rotating the cutting tool to the position where a slight increase of force is required to rotate it further in either direction. The clock gauge 67 is then used to measure the height of the cutting edge 7 on the insert 5. In the alternative method scribe lines on the envelope surface of the cutting tool and on the front face of the tool claming device were brought in line to obtain the desired position of the cutting edge.

Practical tests were carried out according to the method illustrated in Fig. 10 using a group of highly experienced mechanics to compare the results of aligning a cutting tool

using scribe lines with those obtained using the sphere or cylinder and groove method of the invention.

RESULTS OF LABORATORY TEST OF INDEXING OF BORING BAR

Bar used A06F-STFCR 06-R in sleeve 131-2006-A

<u>DEVIATION OF HEIGHT OF OPERATIVE CUTTING EDGE FROM CORRECT VALUE MEASURED IN 1/100 mm MEASURED WITH CLOCK GAUGE</u>

Test Person	Indexing line to line	Indexing with the invention
1	-19	0
2	+ 3	-1
3	0	0
4	+10	-2
5	-10	-1
6	+16	-1
7	+ 2	-1
8	+ 6	-2
9	+14	-2
10	+ 6	-2
Total deviation	Σ 0,86 mm	Σ 0,11 mm
Average deviation	0,86 /10 = 0,086	0,11/10 = 0,011

$$\tan\alpha = \frac{0,086}{4,5} = 0,0191 = 1^\circ\ 5'$$

$$\tan\alpha = \frac{0,011}{4,5} = 0,0024 = 0^\circ\ 8'$$

As can be seen from the table the scribe line method gave an average deviation in cutting edge height of 0,086 mm whereas the method according to the invention gave an average of 0,011 mm. These values correspond to angular deviations of 1° 5′ and 0° 8′ respectively. In other words the use of the

spring loaded device gives more than eight times greater precision than the scribe line method.

Feasible Modifications of the invention

The invention is not solely restricted to the embodiment described and shown in the drawings. Thus the invention may also apply to solutions where the positions of the recesses and spring-loaded devices have been reversed. That is to say the spring loaded device or devices mounted in the envelope surface of the cutting tool and the recesses on the inner surface of the aperture 23. Similarly other combinations of the groove and dimple solutions shown in Fig.4 to 4c are possible for example a combination of Fig. 4 and Fig. 4b.

Although the present invention has been described in connection with preferred embodiments thereof, it will be appreciated by those skilled in the art that additions, deletions, modifications, and substitutions not specifically described may be made without departing from the spirit and scope of the invention as defined in the appended claims.

LIST OF DRAWING REFERENCES

1) Cutting tool
3) Shaft
5) Cutting insert
7) Cutting edge
9) Front end of cutting tool
11) Rear end of cutting tool
13) Planar surface
15) Tool clamping device
17) Clamping screw
19) Longitudinal split
21) "U"-shaped recess
23) Aperture
25) Scribe line on bar
27) Scribe line on front face of tool block
30) Spring loaded device
31) Coil spring
33) Sphere or cylinder
35) Threaded housing
37) Housings upper end
43) Groove
45) Bore with internal thread
47) Sleeve
49) Adaptor
51) Cylindrical elastic cap
53) Front face of tool block
55) Rear face of tool block
57) Side surface of tool block
59) Upper part of block above split
61) Lower part of block below split
63) Upper surface of tool block
65) Screw
67) Clock gauge

CLAIMS

1) A cutting tool system comprising a cutting tool(1) and a tool clamping device (15) where the cutting tool (1) includes at the front end (9) at least one cutting edge (7) and to the rear of said front end a shaft portion (3) and where the tool clamping device comprises a block with an aperture (23), and where the shaft portion (3) is to be clamped in position in the aperture (23) in the tool clamping device (15) said shaft and said aperture having centre lines (CL 1, CL 2) characterized in that
at least one spring loaded device (30) is mounted in one of the tool clamping device (15) or the envelope surface of the shaft portion (3) of the cutting tool in such a way that it can interact with a recess or recesses (29) in the other in order to provide an indication of a desired position prior to clamping by providing a sudden increase in the force necessary to displace the cutting tool from said desired position.

2) A cutting tool system according to claim 1 wherein the shaft portion of the cutting tool is substantially cylindrical and the recess consists of a groove (21) extending the entire length or part of the length of the envelope surface of the shaft portion (3) or inner surface of the aperture (23) said groove being parallel to the centre line (CL) of the shaft portion or tool clamping device.

3) A cutting tool system according to claim 1 wherein the shaft portion (3) of the cutting tool (1) is substantially cylindrical and the recess (21) consist of one dimple or a plurality of dimples extending in a line the entire length or part of the length of the envelope surface of the shaft portion of the cutting tool or inner surface of the aperture (23) said line of dimples being parallel to the centre line (CL) of the shaft portion or tool clamping device (15).

4) A cutting system according to anyone of claims 1-3 wherein the shaft portion (3) of the cutting tool is substantially cylindrical and the recesses (21) consist of at least one groove running round the entire or part of the circumference of the envelope surface of the shaft and lying parallel to a planar surface at right angles to the centre line (CL) of the shaft portion or inner surface of the aperture (23) the grooves being spaced at regular intervals, for example 10mm.

5) A cutting tool system according to claim 1 wherein the shaft portion (3) of the cutting tool (1) is substantially prismatic in cross section and the recesses (21) consist of at least one groove running along the entire width or part of the width of one of the faces of the prismatic form of the envelope surface of the shaft and lying parallel to a planar surface at right angles to the centre line of the shaft portion or said groove/grooves being found on the inner surface of the aperture (23) the grooves being spaced at regular intervals for example 10mm.

6) A cutting tool system according to claim 1 wherein the spring loaded device (30) includes at one end a sphere or a cylinder (33) which is pressed by the spring into a recess having a cross section which is substantially U-shaped (21) said spring being in the form of a coil spring (31) or cap (51) of a material such as rubber with a Young's modulus far lower than that for steel.

7) A cutting tool system according to claim 1 wherein the recess (21) can be in the form of an inverted cone or a groove and is symmetrical, the size of the recess and thc angle of its sides being selected so that when the sphere or cylinder

(33) is seated symmetrically in the recess the centre of the sphere or cylinder parallel to the centre line of the aperture (23) is to be at a greater distance from apex of the recess than a point where said centre line intersects a curve representing a continuation of the circumference of the cutting tool or aperture(23).

8) A cutting tool system according to claim 7 wherein the point angle of the recess lies between 35-85°, preferably 55-65° and recommendably about 60°.

9) A cutting tool (1) comprising at a front end (9) at least one cutting edge (7) and to the rear of said front end a shaft portion (3) which is to be clamped in position in an aperture (23) in a tool clamping device (15), said shaft and said aperture having centre lines CL 1 and CL2.
characterized in that,
at least one recess (29) is provided in the envelope surface of the cutting tool to receive a spring loaded device (30) that provides an indication of the location of the tool when it is in a desired position by providing a sudden increase in the force necessary to displace the cutting tool from said position.

10) A tool-clamping device comprising a block with an aperture (23) in which a shaft portion of a cutting tool can be clamped in position, said aperture having a centre line CL 2
characterized in that,
at least one spring loaded device (30) is mounted in the tool clamping device (15) in such a way that it can interact with a recess or recesses (29) in a cutting tool in order to provide an indication of the location of the tool when it is in a

desired position by providing a sudden increase in the force necessary to displace the cutting tool from said position.

ABSTRACT

A cutting tool system comprising a cutting tool(1) and a tool clamping device (15) where the cutting tool (1) includes at the front end (9) at least one cutting edge (7) and to the rear of said front end a shaft portion (3) and where the tool clamping device comprises a block with an aperture (23), and where the shaft portion (3) is to be clamped in position in the aperture (23) in the tool clamping device (15). The system featuring at least one spring loaded device (30) mounted in one of the tool clamping device (15) or the envelope surface of the shaft portion (3) of the cutting tool in such a way that it can interact with a recess or recesses (29) in the other in order to provide an indication of a desired position prior to clamping by providing a sudden increase in the force necessary to displace the cutting tool from said desired position.

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Fig. 1

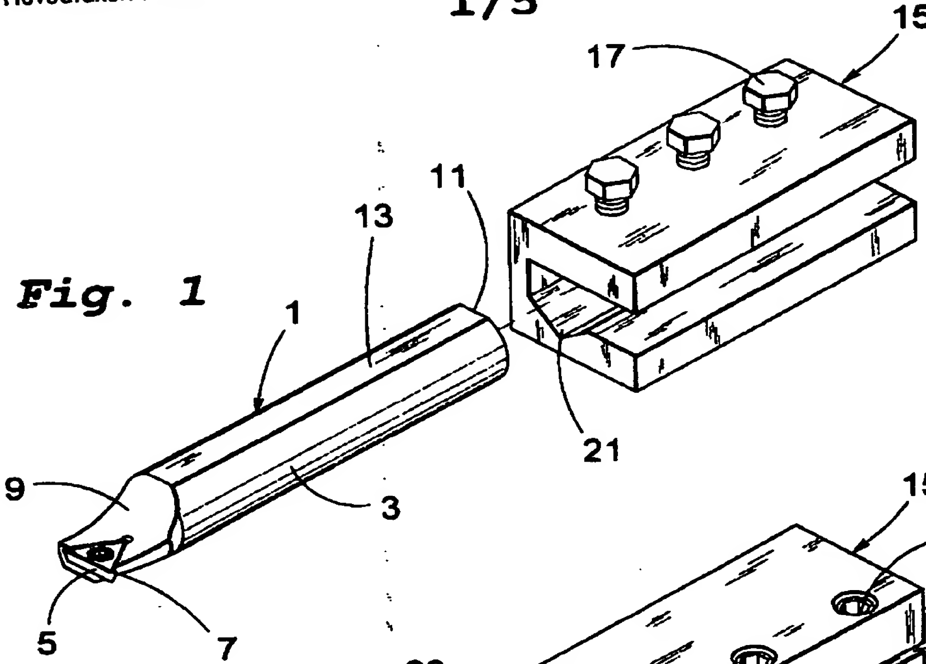


Fig. 2

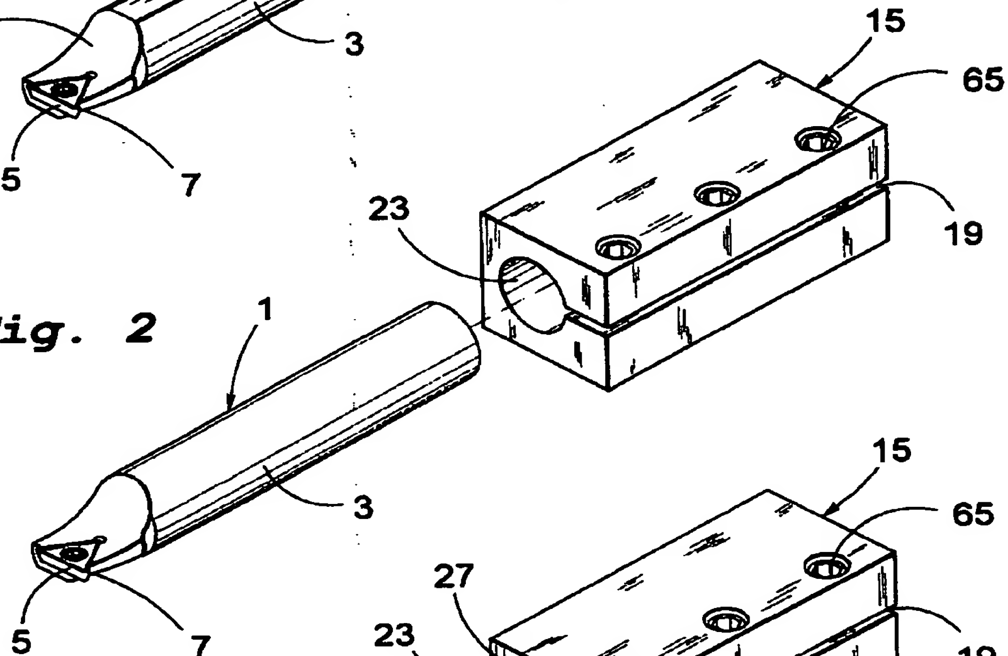
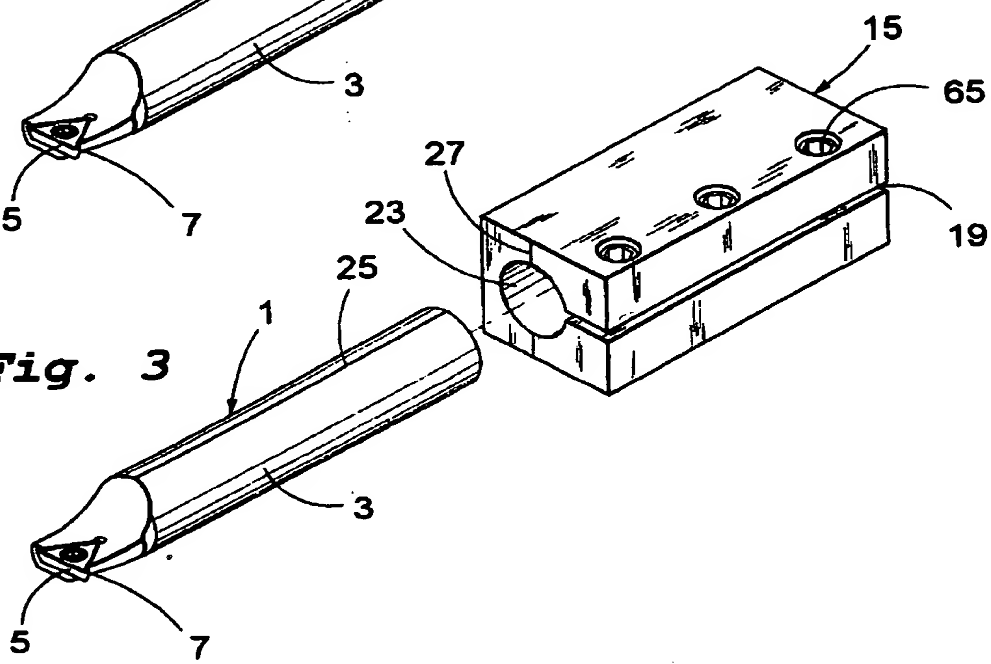


Fig. 3



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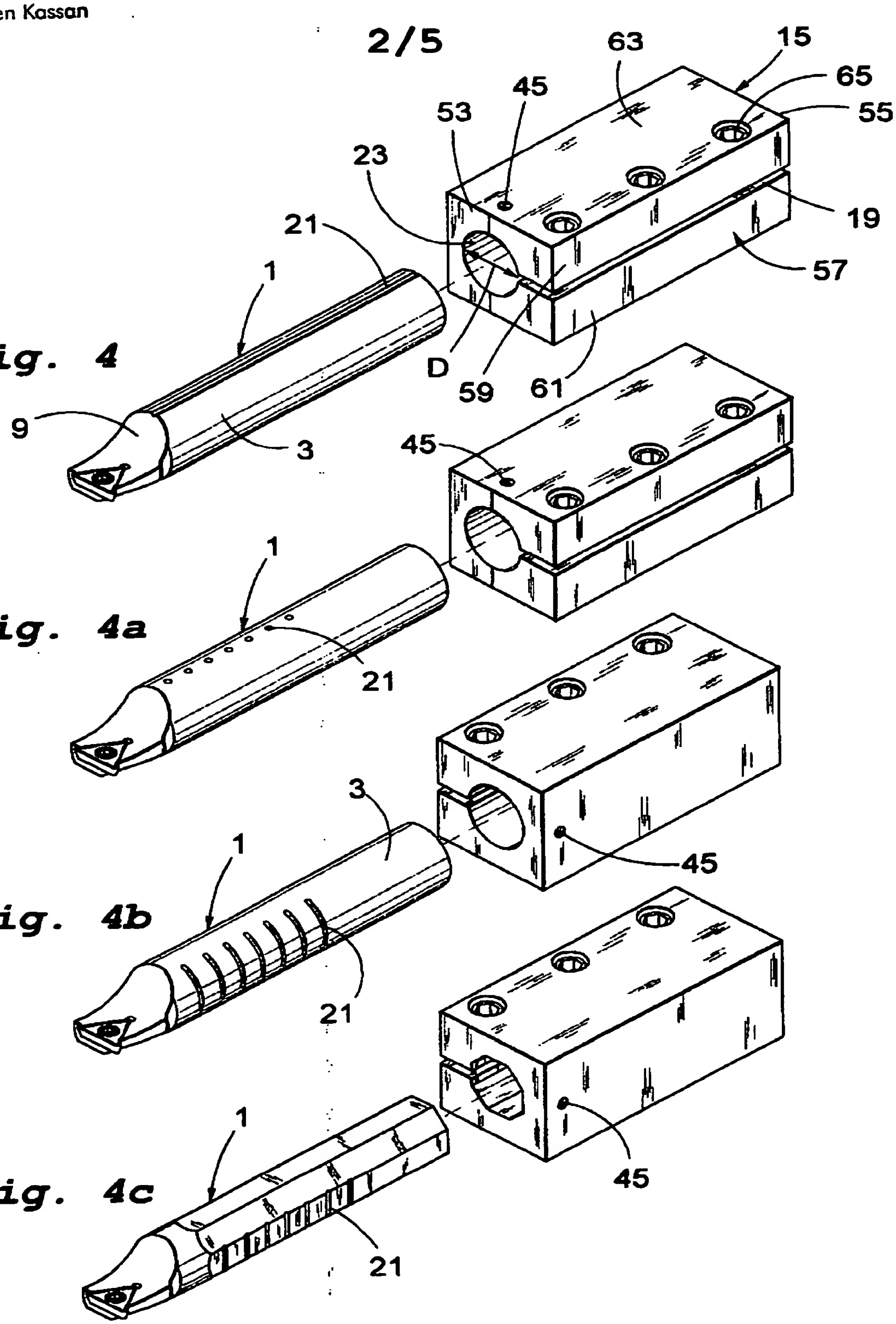

Fig. 4

Fig. 4a

Fig. 4b

Fig. 4c

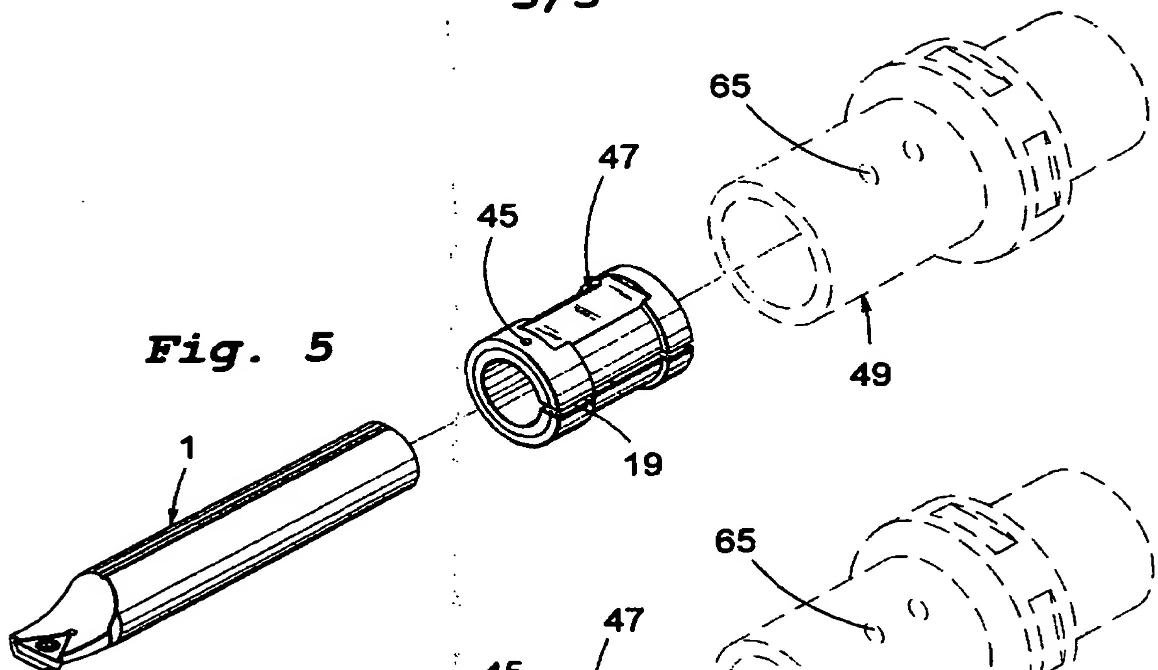

Fig. 5

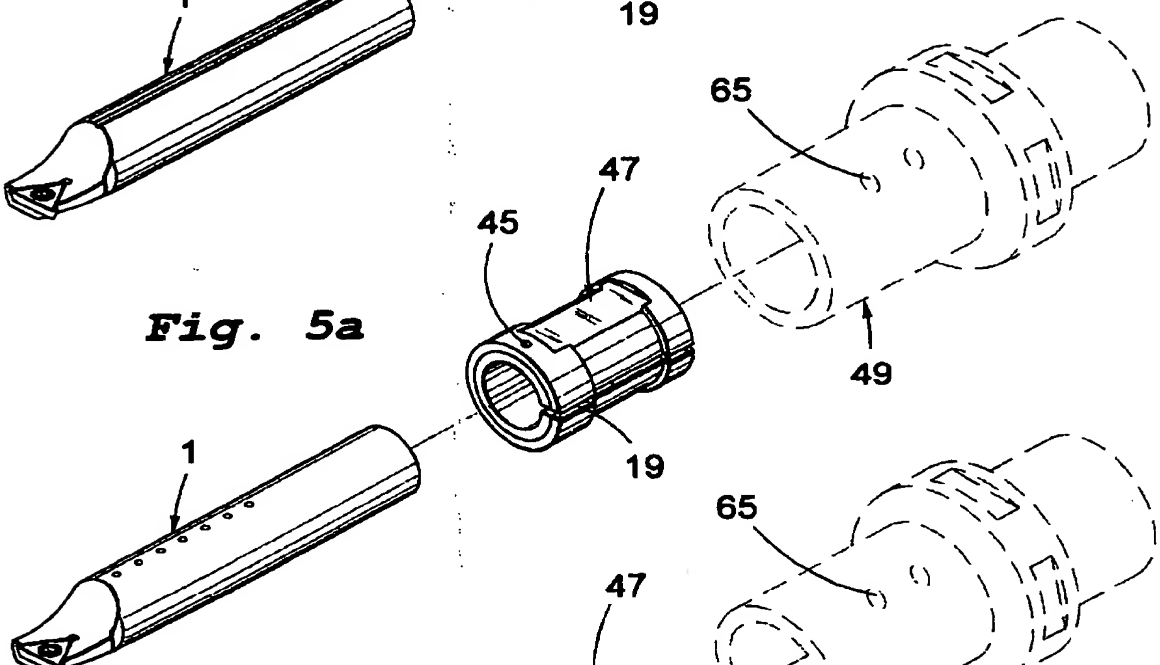

Fig. 5a

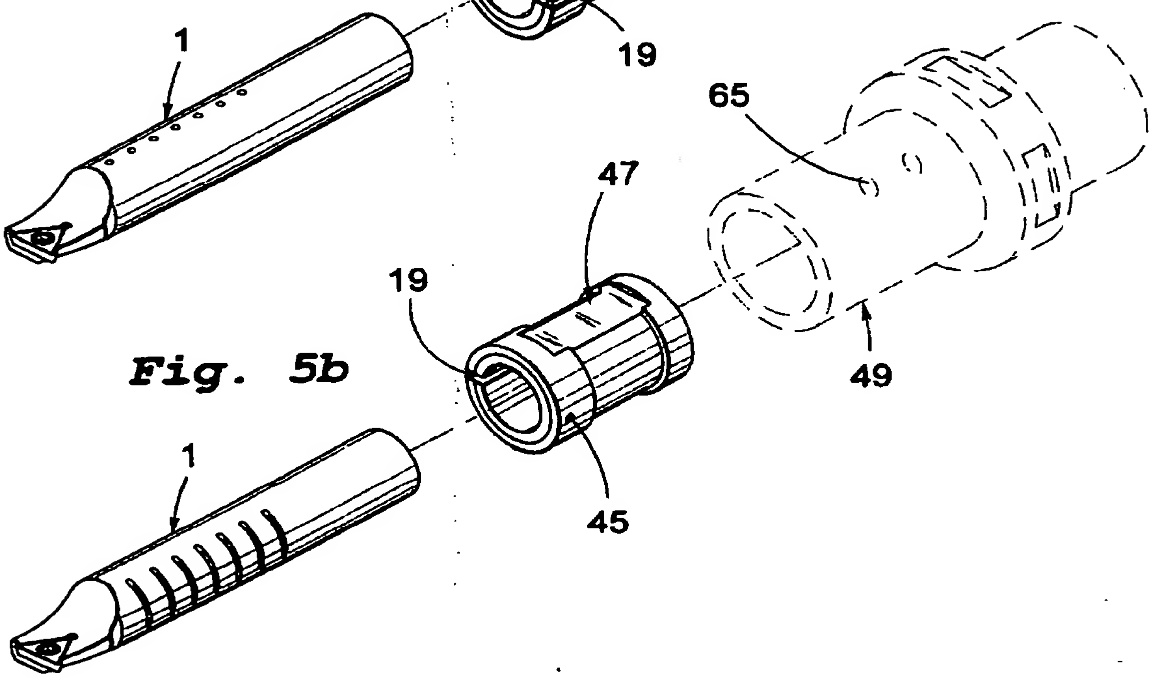

Fig. 5b

Fig. 6

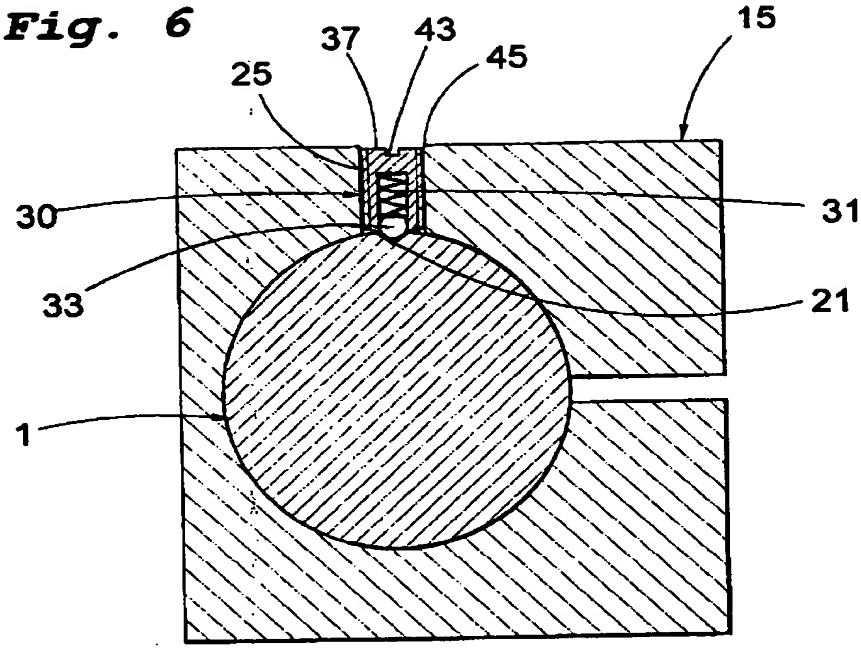

Fig. 7

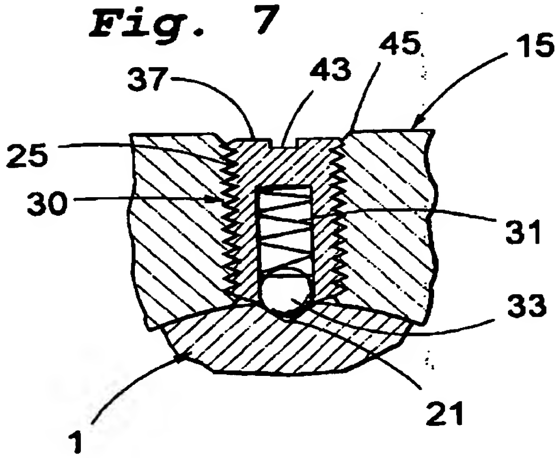

Fig. 8

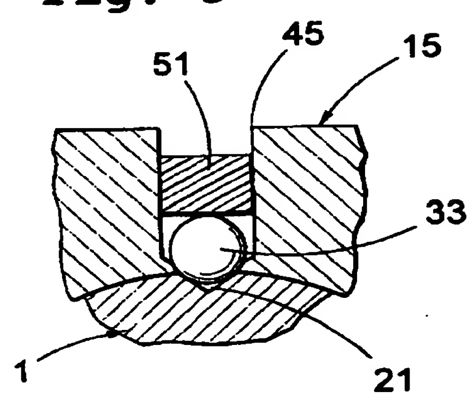

Fig. 9

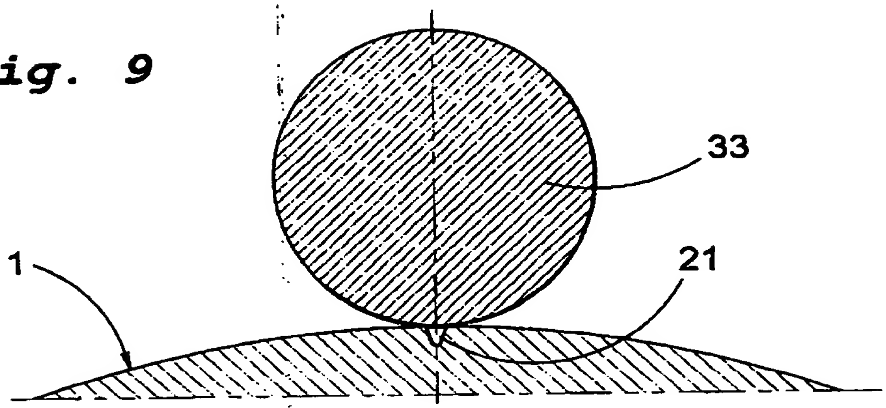

Fig. 10